N93-19151

165

FROM ASTEROID CLUSTERS TO FAMILIES: A PROPOSAL FOR A NEW NOMENCLATURE

P. Farinella[1], D.R. Davis[2], A. Cellino[3], V. Zappalà[3]

1. Dipartimento di Matematica, Università di Pisa, Pisa, Italy
2. Planetary Science Institute, Tucson, Arizona, USA
3. Osservatorio Astronomico di Torino, Pino Torinese, Italy

Abstract. Some confusion on the number, reliability and characteristics of asteroid families is the result of using the single word "family" for naming asteroid groupings identified in very different ways. Here we propose a new terminology which in our opinion would alleviate this problem.

The studies on asteroid families have been often frustrated by the large disagreements existing among family lists and family memberships identified by different investigators (see Carusi and Valsecchi, 1982). A part of the problem certainly arises from the differences in the asteroid population used for the family searches and the corresponding proper orbital elements (which have been derived through different secular perturbation theories). However, such differences are unavoidable, and sometimes may even provide useful insights about the properties of families found in various portions of the proper elements space and/or in various subsets of the asteroid population.

Definitely worse, in our opinion, are the problems caused by the use of different statistical methods for identifying groupings in the proper elements space and for assessing their statistical significance against the background of "field asteroids". Here, confusion and ambiguities arise as a result of using the single word "family" for naming asteroid groupings identified in different ways and subjected to statistical significance tests having various degrees of rigor. This is true in particular when groupings identified "by eye", i.e., found through visual inspection of the asteroid distribution in the proper elements space (such as those of Williams, 1979) are compared with groupings found by fully automated clustering algorithms (such as those of Zappalà et al., 1990, and Bendjoya et al., 1991).

Our scheme (see Figure) recognizes four types of groupings in proper elements space, distinguished by the techniques used to identify them and the significance criteria or tests (possibly) applied. We call "clumps" (or "associations", or *type IV* families) the groupings recognized by visual inspection but not subjected to rigorous tests for significance. On the other hand, groupings shown to be statistically significant (family identification techniques such as that of Zappalà et al. include such significance tests) may be divided into two categories: "clusters" (or *type II* families), for which an unequivocal membership definition is possible through a clearcut separation from the random background and from other groupings; and "clans" (or "tribes", or *type III* families), for which unequivocal membership definition and/or separation from other "clans" is impossible. In other words, "clans" are statistically significant, but lie within a background so dense and/or are so close to each other that they cannot be separated in a clearcut manner, and their membership depends in a sensitive way on the adopted cut–off distance criterion.

Finally, "clusters" and "clans" would be called (*type I*) "families" only when some physical evidence indicates that their members have a genetic relationship, namely are the outcomes of the breakup of a common parent body. This evidence can be based on collisional physics — e.g., the relative velocities inferred from the proper elements differences should be physically reasonable; or it could be based on taxonomy, with the family shown to be a cosmochemically plausible assemblage of asteroid taxonomic types. When this type of physical evidence is missing, observational efforts should be encouraged to obtain the relevant data. Negative evidence about a genetic relationship can also be provided by dynamical arguments, e.g. for asteroid *groups* (such as Phocaeas, Hildas and Cybeles) isolated by mean motion or secular resonances.

We give a few examples of use of the nomenclature described above, applied to the results of Zappalà's et al. search: the three populous Hirayama families (Eos, Themis and Koronis) are of course "type I families"; the Eunomia complex is a set of "clans", or possibly a single large "tribe"; and the Flora region is dominated by a large "clump" or "association".

References

Bendjoya Ph., Slezak E., and Froeschlé C. (1991). The wavelet transform: A new tool for asteroid family determination. Astron. Astrophys., 251, 312–330.

Carusi A., and Valsecchi G.B. (1982) On asteroid classifications in families. Astron. Astrophys. 115, 327–335.

Williams J.G. (1979) Proper elements and family memberships of the asteroids. In Asteroids (T. Gehrels, ed.), pp. 1040–1063. University of Arizona Press, Tucson.

Zappalà V., Cellino A., Farinella P., and Kneževič Z. (1990) Asteroid families. I. Identification by hierarchical clustering and reliability assessment. Astron.J., 100, 2030–2046.

PROPER ELEMENTS SPACE

```
                    eyes              brain
                     +                 +
                   brain            computer

                    CLUMP
                   (type IV)

                  statistically
       NO         significant?

                      YES

          CLAN                  CLUSTER
        (type III)             (type II)

                   plausible
          NO         parent        NO
                     body?

                      YES

                    FAMILY
                   (type I)
```